This technical appendix explains in detail how the BEN computer program calculates the economic benefit a violator gains from delaying or avoiding compliance with environmental regulations. The first section is an introduction to the theory and underlying assumptions of BEN. The second section is a step-by-step explanation of a sample economic benefit calculation.

A. THEORY AND OVERVIEW

Economic benefit represents the financial gains that a violator accrues by delaying and/or avoiding pollution control expenditures. Funds not spent on environmental compliance are available for other profit-making activities or, alternatively, a defendant avoids the costs associated with obtaining additional funds for environmental compliance. (This concept is known in economics as opportunity cost.) Economic benefit is "no fault" in nature: a defendant need not have deliberately chosen to delay compliance (for financial or any other reasons), or in fact even have been aware of its noncompliance, for it to have accrued the economic benefit of noncompliance.

The appropriate economic benefit calculation should represent the amount of money that would make the violator indifferent between compliance and noncompliance. (BEN implicitly assumes a 100-percent probability of the violator paying that sum of money in the form of a civil penalty, but as that probability declines, the amount of money increases that would make the violator indifferent between compliance and noncompliance.) If the enforcement agency fails to recover through a civil penalty at least this economic benefit, then the violator will retain a gain. Because of the precedent of this retained gain, other regulated companies may see an economic advantage in similar noncompliance, and the penalty will fail to deter potential violators. Economic benefit does not represent compensation to the enforcement agency as in a typical "damages" calculation for a tort case, but instead is the minimum amount by which the violator must be penalized so as to return it to the position it would have been in had it complied on time.

The economic benefit calculation must incorporate the concept of the "time value of money." In simple terms, a dollar yesterday is worth more than a dollar today since yesterday's dollar had

investment opportunities. Thus, the further in the past the dollar is, the more it is worth in "present value" terms. The greater the time value of money (i.e., the greater the "discount" or "compound" rate), the more value past costs have in present value terms.

Pollution control expenditures can include: (1) Capital investments (e.g., pollution control equipment), (2) One-time nondepreciable expenditures (e.g., setting up a reporting system, or acquiring land), (3) Annually recurring costs (e.g., operating and maintenance costs, or off-site disposal of fluids from injection wells). Each of these expenditures can be either delayed or avoided. BEN's baseline assumption is that capital investments and one-time nondepreciable expenditures are merely delayed over the period of noncompliance, whereas annual costs are avoided entirely over this period. BEN does allow you, however, to analyze any combination of delayed and avoided expenditures.

BEN derives a violator's economic benefit in several steps. First BEN adjusts compliance costs from the cost estimate date to the date when they would have been expended had the violator complied on time (on-time scenario) and to the date when they will be expended as the violator comes into compliance (delay scenario). Next BEN uses these costs to compute the total cost of complying on-time and of complying late, adjusted for inflation, depreciation and taxes. BEN also calculates the present value of both scenarios as of the date of initial noncompliance, so that they can be compared in a common metric. Then BEN subtracts the delayed scenario present value from the on-time scenario present value to determine the initial economic benefit as of the noncompliance date. Finally, BEN compounds this initial economic benefit forward to the penalty payment date.

A violator may gain illegal competitive advantages in addition to the usual benefits of noncompliance. These may be substantial benefits, but they are beyond the capability of BEN or any computer program to assess. Instead BEN asks you a series of questions about possible illegal competitive advantages so that you may identify cases where they are relevant. If illegal competitive advantage is an issue you should consult the EPA enforcement economics toll-free helpline at 888-ECON-SPT (326-6778) or benabel@indecon.com. If you need legal or policy guidance, please contact Jonathan Libber, the BEN/ABEL coordinator at 202-564-6102, or e-mail him at libber.jonathan@epamail.epa.gov.

B. CALCULATIONS AND SPREADSHEET

BEN references a Microsoft Excel™ spreadsheet to perform all of its economic benefit calculations, although you do not need Excel to run BEN. The data you enter into the program is automatically transferred to the spreadsheet. The spreadsheet calculates economic benefit and returns the result to the program for output. This section illustrates a BEN calculation by taking you step-by-step through relevant portions of the underlying spreadsheet. Italicized comments within brackets are added to explain the calculations, and are not part of the spreadsheet itself.

The spreadsheet is in your BEN folder (on your C drive or wherever else you installed BEN), filename "ben****.xls". (The asterisks represent the most recent year for which EPA has performed updates for the spreadsheet.) You may open the file, but it has been write-protected to preserve the integrity of the calculations. This spreadsheet contains necessary formulas and background information like tax rates, discount rates, and inflation indices. The background information will be updated once a year, but the calculations themselves will remain the same.

1. Inputs and Variables

The first section of the spreadsheet contains the variables entered by the user. These are a prerequisite for the calculations. The following page lists BEN's basic inputs, along with inputs from an example case.

Tax rates are contained in the spreadsheet as tables that contain corporate and individual tax rates and state tax rates from 1987 to 2010, (with rates for future years assumed to remain the same). Annual updates will keep tax rates current and add future years. When you designate a state and tax status for the violator, BEN finds the appropriate federal and state tax rates and calculates a combined tax rate. State taxes are deductible from federal taxes, so the combined tax rate calculation is:

Combined = Federal + (State * (1 - Federal)).

The spreadsheet also contains a table for the BCI, BEN, CCI, CPI, ECIM, ECIW and PCI inflation indices. (See Chapter 3 for a complete explanation of these difference indices.) Inflation indices are more precise than an annual inflation rate, but they require an index value for every relevant month. Therefore, BEN contains a database of monthly index values for every index from 1987 to 2029. Annual updates will keep indices current and add future values. For projected future inflation, BEN extrapolates each cost index forward in time at a separate forecasted rate, which is based upon a consensus forecast for the Consumer Price Index (CPI) and each individual index's historical relationship to the CPI. (The rationale for the calibration of the other indices to the CPI is that the CPI — yet not the more specialized indices — has widely available forecasts for projected inflation.)

Inputs	Example	*Comments*
Case Name	Example Case	
Analyst Name	Jon Analyst	
EPA Region	EPA Region I	
Tax Status	c-corp	*[Also known as "Entity Type"]*
State	MA	
Customized Tax Rates?	n	*[You may customize tax rates, in which case BEN will use the*
Penalty Payment Date (PPD)	01-Jan-1999	*customized rates instead of its internal table]*
Run Name	Test Run	
Discount/Compound Rate	10.0%	*[Ben calculates this from tax status, state, and relevant dates]*
Customized Discount/Compound Rate?	n	*[You may customize the discount rate]*
Customized Specific Cost Estimates?	n	*[You may customize the specific cost estimate screen]*
Capital Investment:		
Cost Estimate	$1,000,000	
Cost Estimate Date	01-Jan-1992	
Cost Index for Inflation	PCI	*[You may choose from several indices]*
Cost Index Value	359.500	*[This is the index value as of the cost estimate date]*
Number of Replacement Cycles	1	*[This is the default value]*
Useful Life of Capital Equipment	15	*[This is the default value]*
Projected Rate for Future Inflation	2.2%	*[This is the default value]*
One-Time, Nondepreciable Expenditure:		
Cost Estimate	$100,000	
Cost Estimate Date	01-Jan-1992	
Cost Index for Inflation	PCI	*[You may choose from several indices]*
Cost Index Value	359.500	*[This is the index value as of the cost estimate date]*
Tax Deductible?	Y	*[This is the default setting]*
Annually Recurring Costs:		
Cost Estimate	$10,000	
Cost Estimate Date	01-Jan-1992	
Cost Index for Inflation	PCI	*[You may choose from several indices]*
Cost Index Value	359.500	*[This is the index value as of the cost estimate date]*
Noncompliance Date (NCD)	01-Jan-1992	
Compliance Date (CD)	01-Jan-1997	
Question 1	n	*[These are the competitive advantage questions. If you*
Question 2	n	*answer yes to any of them a warning that possible illegal*
Question 3	n	*competitive advantage exists appears in the results.]*
Question 4	n	
Question 5	n	
Question 6	n	

2. Discount/Compound Rate Calculation

Once the entity type and relevant dates have been entered, BEN can then calculate the violator's discount/compound rate. This is based on entity type and financial information from the date of noncompliance to the penalty payment date. (An industry- or company-specific discount rate can be calculated by experts, but cannot be calculated by BEN.) The discount/compound rate quantifies the time value of money. BEN discounts and compounds all cash flows at the cost of capital, averaged over the time period from the noncompliance date to the compliance or penalty payment date, whichever is later.

For a for-profit entity's discount/compound rate, BEN uses the weighted-average cost of capital (WACC) for a typical company, reflecting the cost of debt and equity capital weighted by the value of each financing source. A company must on average earn a rate of return necessary to repay its debt holders (e.g., banks, bondholders) and satisfy its equity owners (e.g., partners, stock holders). While companies often earn rates in excess of their WACC, companies that do not on average earn at least their WACC will not survive (i.e., their lenders will not receive their principal and/or interest payments, and their owners will be dissatisfied with their returns). The WACC represents the return a company can earn on monies not invested in pollution control, or, viewed alternatively, represents the avoided costs of financing pollution control investments. Thus, a company should make its business decisions by discounting cash flows at its WACC, and BEN follows the internal analysis a company will normally perform.

For a not-for-profit discount/compound rate, BEN uses a typical municipality's cost of debt, based on interest rates for general obligation bonds.

Discount/Compound Rate Calculation

Notes:

(1) Corporate Bonds: All Industries; Federal Reserve Bulletin, Table 1.35. *[Average industry cost of debt]*

(2) Combined state/federal marginal tax rates: federal+(state*(1-federal)); Federation of Tax Administrators.

(3) Calculated as: (1) * (100%-(2)).

(4) Standard & Poor's Analyst's Handbook, S&P Industrials Sample Balance Sheet, Liabilities section. *[Average Industry debt weight]*

(5) Federal Reserve Bulletin Table 1.35. *[Used as a risk-free rate, Capital Asset Pricing Model (CAPM)]*

(6) Beta is a measure of risk relative to the overall market. *[A value of 1.00 assumes risk is same as overall market]*

(7) Differences of historical arithmetic mean returns from 1926 to prior year; Ibbotson Associates Handbook, *[Representing expected return on an average risk investment]*

(8) Calculated as (6) * (7). *[This equals (7) for average risk, because average risk has a beta of 1]*

(9) Calculated as (5) + (8). *[Risk-free rate of return plus the risk premium]*

(10) Calculated as 100% - (4). *[Total financing - debt = equity financing]*

(11) Calculated as (3) * (4) + (9) * (10). *[(Debt cost x debt weight) + (equity cost x equity rate)]*

average from: 1992 to: 1998 = **10.0%** [*Final result*]

YEAR	(1) Cost of Debt	(2) Tax Rate	(3) After-Tax Debt Cost	(4) Debt Weight	(5) 5-Year Treasury Notes	(6) Beta	(7) Intermed. Horizon Risk Prem	(8) Company Risk Premium	(9) Equity Cost	(10) Equity Weight	(11) Rate
1987	9.9%	40.3%	5.9%	43.0%	7.94%	1.00	7.7%	7.7%	15.6%	57.0%	
1988	10.2%	40.3%	6.1%	52.0%	8.47%	1.00	7.3%	7.3%	15.8%	48.0%	
1989	9.7%	40.3%	5.8%	49.0%	8.50%	1.00	7.4%	7.4%	15.9%	51.0%	
1990	9.8%	40.3%	5.9%	50.0%	8.37%	1.00	7.8%	7.8%	16.2%	50.0%	
1991	9.2%	40.3%	5.5%	49.0%	7.37%	1.00	7.5%	7.5%	14.9%	51.0%	
1992	8.6%	40.3%	5.1%	47.0%	6.19%	1.00	7.7%	7.7%	13.9%	53.0%	**9.8%**
1993	7.5%	41.2%	4.4%	47.0%	5.14%	1.00	7.6%	7.6%	12.7%	53.0%	**8.8%**
1994	8.3%	41.2%	4.9%	44.0%	6.69%	1.00	7.6%	7.6%	14.3%	56.0%	**10.2%**
1995	7.8%	41.2%	4.6%	42.0%	6.38%	1.00	7.4%	7.4%	13.8%	58.0%	**9.9%**
1996	7.7%	41.2%	4.5%	37.0%	6.18%	1.00	7.8%	7.8%	14.0%	63.0%	**10.5%**
1997	7.5%	41.2%	4.4%	37.0%	6.22%	1.00	7.9%	7.9%	14.1%	63.0%	**10.5%**
1998	7.0%	41.2%	4.1%	37.0%	5.50%	1.00	8.2%	8.2%	13.7%	63.0%	**10.2%**

3. Specific Cost Estimates

After the compound/discount rate, BEN calculates specific cost estimates. This calculation adjusts costs from the cost estimate date to the date on which they should have been spent (on-time compliance scenario) and the date on which they will be spent (delay compliance scenario). These calculations are visible and may be altered on the specific cost estimates screen. (If the violator will avoid compliance completely, rather than simply delay it, you must modify this screen by changing the delay cost of compliance to zero.) The specific cost estimate calculations are shown below.

Calculations for Specific Cost Estimates

	Compliance Start:		Replacement Cycle Start:	
	On-Time	Delay	On-Time	Delay
Date:	01-Jan-1992	01-Jan-1997	01-Jan-2007	01-Jan-2012
Capital Investment:				
Original Cost Estimate	$1,000,000	$1,000,000	$1,000,000	$1,000,000
	÷	÷	÷	÷
PCI Value as of Cost Estimate Date,	359.500	359.500	359.500	359.500
01-Jan-1992	x	x	x	x
PCI Value as of Specific Estimate Date	359.500	383.300	471.943	526.192
	=	=	=	=
Specific Cost Estimate,	**$1,000,000**	**$1,066,203**	**$1,312,777**	**$1,463,677**
reflecting implicit annualized inflation rate of:	N/A	1.3%	1.8%	1.9%
One-Time, Nondepreciable Expenditure:				
Original Cost Estimate	$100,000	$100,000		
	÷	÷		
PCI Value as of Cost Estimate Date,	359.500	359.500		
01-Jan-1992	x	x		
PCI Value as of Specific Estimate Date	359.500	383.300		
	=	=		
Specific Cost Estimate,	**$100,000**	**$106,620**		
reflecting implicit annualized inflation rate of:	N/A	1.3%		

Note that the specific cost estimate and the original cost estimate are the same here for the "Compliance Start: On-Time" scenario. This is because the cost estimate was made on the on-time date, so no inflation adjustment was needed.

4. Capital and One-Time Costs

Now BEN can calculate the total costs of compliance for both scenarios. First it calculates the costs of compliance as of the on-time and delay scenarios. Then BEN adjusts both sets of costs to the noncompliance date so that they can be compared to each other.

Each scenario is divided into an initial cycle and a replacement cycle. The initial cycle covers the cost of installing equipment, while the replacement cycle covers the cost of replacing that

equipment when its useful life is over. The number of replacement cycles defaults to one, and the useful life of equipment defaults to fifteen years.

Because of the time value of money, the farther in the future costs are, the less value they have in present terms. Therefore, replacement cycles after the first one have almost no impact on economic benefit. They are cumulatively calculated from the value of the first replacement cycle.

The present value (as of the noncompliance date) of each date's cash flow is equal to the cash flow multiplied by that date's present value factor. The PV factor uses the discount/compound rate to determine a dollar's equivalent value in noncompliance date dollars. Therefore, the PV factor for any date is equal to the sum of one plus the discount/compound rate, raised to the difference in the number of years (including any fractions) between that date and the noncompliance date.

A) On-Time Capital & One-Time Costs: Initial Cycle

	01-Jan-1992	01-Jul-1992	01-Jul-1993	01-Jul-1994	01-Jul-1995	01-Jul-1996	01-Jul-1997	01-Jul-1998	01-Jul-1999
One-Time, Nondepreciable Expenditure	(100,000)	*[From specific cost estimates]*							
Capital Investment	(1,000,000)	*[From specific cost estimates]*							
Depreciation	0	(142,860)	(244,897)	(174,935)	(124,953)	(89,243)	(89,243)	(89,243)	(44,626)
Marginal Tax Rate	40.3%	40.3%	41.2%	41.2%	41.2%	41.2%	41.2%	41.2%	41.2%
Net After-Tax Cash Flow	(1,059,700)	57,573	100,898	72,073	51,481	36,768	36,768	36,768	18,386
PV Factor: Adjusts Cash Flow to NCD	1.0000	0.9536	0.8669	0.7881	0.7164	0.6511	0.5919	0.5381	0.4892
PV Cash Flow as of NCD	(1,059,700)	54,900	87,468	56,800	36,883	23,941	21,765	19,786	8,995

Net Present Value (NPV) as of NCD:	
Initial Cycle	($749,162)
Subsequent Replacement Cycles	($216,058)
Total -- All Cycles	**($965,220)**

[Companies may deduct the depreciation of capital equipment from their taxable income. Below is the standard 7-year depreciation schedule, using the half-year convention.]

Depreciation (MACRS):	14.2860%	24.4897%	17.4935%	12.4953%	8.9243%	8.9243%	8.9243%	4.4626%

B) Delay Capital & One-Time Costs: Initial Cycle

	01-Jan-1997	01-Jul-1997	01-Jul-1998	01-Jul-1999	01-Jul-2000	01-Jul-2001	01-Jul-2002	01-Jul-2003	01-Jul-2004
One-Time, Nondepreciable Expenditure	(106,620)	*[From specific cost estimates]*							
Capital Investment	(1,066,203)	*[From specific cost estimates]*							
Depreciation	0	(152,318)	(261,110)	(186,516)	(133,225)	(95,151)	(95,151)	(95,151)	(47,580)
Marginal Tax Rate	41.2%	41.2%	41.2%	41.2%	41.2%	41.2%	41.2%	41.2%	41.2%
Net After-Tax Cash Flow	(1,128,896)	62,755	107,577	76,845	54,889	39,202	39,202	39,202	19,603
PV Factor: Adjusts Cash Flow to NCD	0.6206	0.5919	0.5381	0.4892	0.4446	0.4042	0.3675	0.3341	0.3036
PV Cash Flow as of NCD	(700,589)	37,148	57,891	37,593	24,405	15,846	14,405	13,096	5,952

Net Present Value (NPV) as of NCD:	
Initial Cycle	($494,254)
Subsequent Replacement Cycles	($149,541)
Total -- All Cycles	**($643,796)**

A) On-Time Capital & One-Time Costs: First Replacement Cycle

	01-Jan-2007	01-Jul-2007	01-Jul-2008	01-Jul-2009	01-Jul-2010	01-Jul-2011	01-Jul-2012	01-Jul-2013	01-Jul-2014
One-Time, Nondepreciable Expenditure	0	*[Zero because this is the replacement cycle, and one-time costs do not occur again by definition]*							
Capital Investment	(1,312,777)	*[From specific cost estimates]*							
Depreciation	0	(187,543)	(321,495)	(229,651)	(164,035)	(117,156)	(117,156)	(117,156)	(58,584)
Marginal Tax Rate	41.2%	41.2%	41.2%	41.2%	41.2%	41.2%	41.2%	41.2%	41.2%
Net After-Tax Cash Flow	(1,312,777)	77,268	132,456	94,616	67,583	48,268	48,268	48,268	24,137
PV Factor: Adjusts Cash Flow to NCD	0.2391	0.2281	0.2073	0.1885	0.1713	0.1558	0.1416	0.1287	0.1170
PV Cash Flow as of NCD	(313,940)	17,625	27,460	17,832	11,579	7,518	6,833	6,212	2,824

Total NPV of First Replacement Cycle as of NCD	($216,058)	
"i", where i = (1+futureinflation)/(1+discountrate)	0.9291	
"u", where u = useful life of capital equipment	15	
"n", where n = number of replacement cycles	1	
"f", where f = sum [from i = 1 to i = n] of: r ^ (u * (i-1))	1.0000	[*This is where the value of future replacement cycles is calculated]*
Total NPV of All Replacement Cycles as of NCD	**($216,058)**	= f * First Replacement Cycle

	Depreciation (MACRS):	14.2860%	24.4897%	17.4935%	12.4953%	8.9243%	8.9243%	8.9243%	4.4626%

B) Delay Capital & One-Time Costs: First Replacement Cycle

	01-Jan-2012	01-Jul-2012	01-Jul-2013	01-Jul-2014	01-Jul-2015	01-Jul-2016	01-Jul-2017	01-Jul-2018	01-Jul-2019
One-Time, Nondepreciable Expenditure	0								
Capital Investment	(1,463,677)								
Depreciation	0	(209,101)	(358,450)	(256,048)	(182,891)	(130,623)	(130,623)	(130,623)	(65,318)
Marginal Tax Rate	41.2%	41.2%	41.2%	41.2%	41.2%	41.2%	41.2%	41.2%	41.2%
Net After-Tax Cash Flow	(1,463,677)	86,150	147,681	105,492	75,351	53,817	53,817	53,817	26,911
PV Factor: Adjusts Cash Flow to NCD	0.1484	0.1416	0.1287	0.1170	0.1064	0.0967	0.0879	0.0799	0.0726
PV Cash Flow as of NCD	(217,282)	12,195	19,005	12,342	8,014	5,202	4,729	4,299	1,954

Net Present Value (NPV) as of NCD:		
Total NPV of First Replacement Cycle as of NCD	($149,541)	
Total NPV of All Replacement Cycles as of NCD	**($149,541)**	*[Calculated using the same formula as on-time all replacement cycles above]*

5. Avoided Annually Recurring Costs

Annual costs are avoided, not merely delayed. Therefore BEN does not need to calculate and compare two different scenarios for annual costs. Instead, it computes the costs avoided each year, then adjusts those costs to the noncompliance date. Finally it adds the present values of the costs avoided each year to compute the total net present value of avoided costs.

C) Avoided Annually Recurring Costs

PCI value as of cost estimate date= 359.500

PCI mid-point value:	356.100	359.400	368.000	381.900	381.800
Period of Avoided Annual Costs; From:	01-Jan-1992	01-Jan-1993	01-Jan-1994	01-Jan-1995	01-Jan-1996
To:	31-Dec-1992	31-Dec-1993	31-Dec-1994	31-Dec-1995	31-Dec-1996
Annual Costs Avoided	(9,933)	(9,997)	(10,236)	(10,623)	(10,649)
Marginal Tax Rate	40.3%	41.2%	41.2%	41.2%	41.2%
Net After-Tax Cash Flow	(5,930)	(5,878)	(6,019)	(6,246)	(6,262)
PV Factor: Adjusts Cash Flow to NCD	0.9535	0.8667	0.7879	0.7163	0.6511
PV Cash Flow as of NCD	(5,654)	(5,095)	(4,742)	(4,474)	(4,077)

NPV of Avoided Annual Costs as of NCD ($24,042)

Note that BEN determines the cost index value for the midpoint of the period in question to account for inflation. BEN also adjusts the annual cost for any partial years.

6. Economic Benefit Results

Now that BEN has computed the present values (PVs) of complying on-time and complying delayed, it compares the two. Economic benefit is the PV of complying on-time, minus the PV of complying delayed, plus the PV of the avoided annually recurring costs. The initial economic benefit is calculated as of the noncompliance date, and then brought forward to the penalty payment date at the discount/compound rate.

The initial economic benefit is multiplied by the sum of one plus the discount/compound rate, raised to the difference in the number of years (including any fractions) between the noncompliance and penalty payment dates.

Run Name = Test Run

Present Values as of Noncompliance Date,	01-Jan-1992	
A) On-Time Capital & One-Time Costs	$965,220	*[Sum from on-time scenario calculations]*
B) Delay Capital & One-Time Costs	$643,796	*[Sum from delay scenario calculations]*
C) Avoided Annually Recurring Costs	$24,042	*[Sum from avoided annually recurring cost calculation]*
D) Initial Economic Benefit (A-B+C)	$345,466	*[Economic benefit as of the date of noncompliance]*
E) Final Econ. Ben. at Penalty Payment Date,		
01-Jan-1999	**$673,567**	*[Final result, economic benefit as of the penalty payment date]*